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Montana Department of Fish, Wildlife & Parks

MIDDLE CLARK FORK RIVER FISHERY MONITORING STUDY:

Evaluation of the Effects of Pulp and Paper Mill Effluents on the Fish Population

by

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Background

In July of 1983 Champion International Corporation applied to the Water Quality Bureau of the Montana Department of Health and Environmental Sciences for a modification of their waste water discharge permit for the Clark Fork River. If granted, the modified discharge permit would allow Champion to release pulp mill effluents into the Clark Fork River on a year-round basis. Under its existing permit the mill was limited to discharging pulp mill effluents only during spring high water. The permit modification was requested because Champion indicated its rapid infiltration system, a collection of gravel ponds to treat effluents, was becoming clogged to the extent that treated effluents would have to be released year-round.

After a preliminary environmental review, the Water Quality Bureau issued a temporary permit on April 10, 1984, which allowed Champion to release treated pulp mill effluents into the Clark Fork River on a year-round basis for two years. This led to an intense debate over existing and future impacts of pulp mill effluents on the river. Trout Unlimited and other environmental groups demanded an Environmental Impact Statement be completed before issuance of a permanent modified permit in two years. This was followed by numerous negotiations between Champion and the groups in an attempt to work out an agreement that would be acceptable to all sides and keep the issue out of court.

By the end of March 1984 a final agreement was reached that embodied the following points:

1. The State of Montana would prepare an Environmental Impact Statement at a cost of $200,000 before issuing a permanent modified discharge permit.

2. The Montana Department of Health and Environmental Sciences would monitor water quality from Turah to the Idaho line and attempt to identify all major sources of pollution and evaluate effects of pulp mill effluents on the water quality of the Clark Fork River. In conjunction Idaho agencies would test for impacts on the river in Idaho, including Lake Pend Oreille.

3. The Montana Department of Fish, Wildlife and Parks would undertake a two-year $100,000 study financed by Champion to evaluate effects of pulp mill effluents on the Clark Fork River fishery.

4. Champion agreed to sponsor an alternative methods study to consider technologies that would reduce or permanently eliminate discharges of pulp mill effluents into the river.

5. A twelve member technical advisory committee would meet on a regular basis to oversee the process. The committee included the broad based representation of Trout Unlimited, the Idaho Wildlife Federation, the Montana Environmental Information Center, the Green Monarch Coalition, Missoula/Mineral/Sanders County Commissioners Association, the Missoula County Health Department, the Water Quality Bureau, Fish, Wildlife and Parks, and Champion International Corporation.

Although the agreement did not represent a final solution, a thorough two-year study would begin to provide information needed to evaluate influences of the Champion Mill on the Clark Fork River.

Scope of the Middle Clark Fork Fishery Study

The study area extends for about 120 miles from Milltown Dam to the confluence of the Flathead River. To evaluate the river's ability to safely assimilate additional quantities of pulp mill wastes, the current status of sport fish populations must be determined. Although fifteen species of fish are known to occur in the middle Clark Fork River, the bulk of the sport fishery is provided by rainbow trout along with a few cutthroat, brown and bull trout. The study is attempting to evaluate effects of pulp mill effluents on trout populations by assessing trout population characteristics in the river in areas upstream and downstream from the pulp mill effluent and by monitoring trout reproductive success in areas upstream and downstream from the effluent.

Trout population characteristics are being assessed by making population estimates. Factors which are being estimated include the number and biomass of trout per mile, species composition, condition factors, growth rates, age structure and mortality rates. Fish are being collected to make trout population estimates using boom suspended electrofishing apparatus. Much of the field work for this phase of the study is being accomplished at night because efficiency of the electrofishing system is significantly better at night than during day time. Trout population characteristics are being compared in study areas upstream and downstream from the pulp mill effluent to evaluate influences of the mill on the sport fishery.

Trout reproductive success is being monitored through a bioassay of trout egg and fry survival in the intergravel environment in study sites upstream and downstream from the pulp mill effluent. Egg and fry survival are being monitored for brown trout, a fall spawner. Egg and fry survival are being evaluated because the egg through emergent fry stage in the life cycle of trout may be relatively more vulnerable to possible influences of pulp mill pollutants than life stages after the trout fry have emerged from the spawning gravels.

Trout spawn in relatively shallow gravelly areas of the river with moderate current velocity. After a depression is dug in the spawning gravel by a female, eggs deposited in the depression by the female are fertilized by an accompanying male and covered over with four to eight inches of spawning gravel. Water quality factors of possible concern in the intergravel environment which could be influenced by pulp mill effluents include dissolved oxygen, pH, ammonia and fine sediments. Additional water quality parameters of concern may be identified during the course of investigation.

Study Design Problems

There were several problems in designing this study to evaluate effects of pulp mill effluents on the sport fishery. First, the study was intended to document an impact from year round discharge of effluent from Champion's mill after the discharges had already begun. Second, there was very little baseline information on the condition of fish populations in areas downstream from the Champion discharge prior to the year-round discharge situation which now occurs. Third, the time frame for the study to assess impacts of the pulp mill was limited to two summer and one winter field seasons. This time frame was too short to provide an adequate assessment. Fourth, there are many other water quality problems in addition to pulp mill effluents which may affect the Clark Fork River fishery. Additional water quality factors which may be influencing the fishery include Missoula sewage treatment plant

effluents, potentially toxic heavy metals originating from mine tailings in the upper Clark Fork drainage and fine sediments originating from various human related activities which could impair trout food production or trout reproductive success.

For these reasons, the scope of the study was broadened with additional funding and assistance being provided by the Department of Fish, Wildlife & Parks. A study was funded by the department to determine the relative importance of various tributaries as sources of recruitment for Clark Fork River trout populations. In addition, resident sport fishery values of the tributaries are being assessed and appropriate management recommendations will be made to maintain or improve fishery values of important tributaries.

To assist in identifying the potential influence of toxic metals on aquatic biota, DFWP is analyzing crayfish tissue samples. Potentially toxic heavy metals originating from mine tailings in the upper Clark Fork drainage are gradually diluted as the Clark Fork receives more good quality dilution water from downstream tributaries. However, monitoring has not been intensive enough, particularly from Milltown Dam downstream, to determine how often, if at all, metals criteria are exceeded. Crayfish were chosen as an indicator organism because their movements are confined to a relatively small area. Metals concentrations in crayfish exoskeletons may prove to be a good integrator of past history of exposure to metals.

The Department of Fish, Wildlife and Parks is also assessing the potential influence of pulp mill effluents on the taste of sport fish in the Clark Fork River. Taste tests will be conducted at an Oregon State University lab to evaluate the concentration at which pulp mill effluents adversely taint the taste of desirable sport fish.

The Department of Fish, Wildlife and Parks also believes that there is a need for a comprehensive evaluation of the Clark Fork River system which cannot be accomplished within the scope of ongoing studies. The comprehensive study should include quantification of instream flow requirements for sport fish in the main river as well as major tributaries, expand sampling to below the confluence of the Flathead River, assess seasonal and temporal distribution and movements of sport fish during both juvenile and adult life stages and identify interactions between fish populations and water quality relative to the influence of tributary streams.

Some of the above mentioned activities will be studied under continued redirection of department effort to the Clark Fork River. New funding will probably be required to complete portions of the comprehensive evaluation. Although the comprehensive evaluation cannot be completed in the short time frame required for the Champion Environmental Impact Statement, the data collected to that date will be made available and used.

Outline
Middle Clark Fork River Fishery Monitoring Study

I. Assessment of Influences of Pulp Mill Effluents on Trout Population Characteristics Including:

1. Number and Biomass (pounds) of Trout/Mile
2. Trout Species Composition
3. Condition Factors
4. Growth Rates
5. Age Structure
6. Mortality Rates

Method: Fish are being sampled with boom suspended electrofishing apparatus and estimates are being made using a mark/recapture technique.

II. Assessment of Influences of Pulp Mill Effluents on Trout Reproduction. Bioassay of brown trout egg and sac fry survival in the intergravel environment. Intergravel water quality parameters of possible concern which could be influenced by pulp mill waste products include dissolved oxygen, pH, ammonia and fine sediments. Bioassay sites include:

1. Council Grove Site - just upstream from Champion effluent
2. Champion site - immediately downstream from Champion effluent
3. Cyr site - downstream from the end of the pulp mill effluent mixing zone (about 25 miles downstream from the mill)

Method: Trout egg and fry survival are being monitored with fiberglass screen egg bags placed in the intergravel environment and with fry emergence traps placed over redds. Intergravel water quality samples are being collected using standpipes. Stream substrate samples are being collected using a McNeil core sampler.

III. Assessment of the Potential Influence of Toxic Heavy Metals on Aquatic Biota. Crayfish were chosen as an indicator organism because their movements are confined to a relatively small area. Toxic metals concentrations in crayfish exoskeletons may prove to be a good integrator of past history of exposure of an indicator organism to metals. Sampling locations for crayfish include below Milltown Dam, below the Missoula sewage outfall, below the Champion outfall, in the Bitterroot River (control), near Superior, below the Flathead River, below Thompson Falls Reservoir and below Noxon Reservoir.

IV. A more comprehensive evaluation of the Clark Fork River system which cannot be accomplished within the scope of ongoing studies is needed. The comprehensive study should include quantification of instream flow requirements for sport fish in the river as well as major tributaries, expand sampling to below the confluence of the Flathead River, assess seasonal and temporal distribution and movements of sport fish during both juvenile and adult life stages and identify interactions between fish populations and water quality relative to the influence of tributary streams.

Preliminary Findings

1. Fifteen species representing six families of fish are found in the middle Clark Fork River between Milltown Dam and the confluence of the Flathead River (Table 1). Rainbow trout provide the bulk of the sport fishery along with a few brown, westslope cutthroat and bull trout.

2. Brown trout egg survival rates were lower at sites 2 and 3, Champion and Cyr, downstream from the pulp mill effluent than at site 1, Council Grove, the upstream control (Tables 2 and 10).

3. Lower egg survival rates occurred at Champion and Cyr even though measured gravel permeabilities were consistently higher at these sites compared to the control (Table 5). If other factors remain constant, higher permeability should enhance egg survival by increasing the rate of oxygen supply to incubating eggs.

4. Measurements of apparent velocity in the intergravel environment were very limited. However, apparent velocities monitored at each bioassay site from late February through early March indicated intergravel apparent velocity was highest at Cyr, lowest at Champion and intermediate at Council Grove (Table 4). Considerable difficulty was encountered in developing reliable techniques for measuring apparent velocity in the intergravel environment of the middle Clark Fork River. This accounts for the limited number of measurements made during the brown trout incubation period in 1984-85. Field experiments indicated standard standpipe methods for measuring apparent velocity were unsuitable for use in the Clark Fork because groundwater does not flow parallel to surface water. This violates a basic assumption for standpipe methods that groundwater does flow parallel to surface water. To replace standpipes, a variety of sizes and types of seepage meters were constructed and tested to measure apparent velocity. The limited findings in Table 4 are based on measurements of apparent velocity from these seepage meters.

5. If other factors remain constant, higher apparent velocity should enhance egg survival by increasing the rate of oxygen supply to incubating eggs.

6. Dissolved oxygen concentrations in the intergravel environment ranged to considerably lower levels at Champion and Cyr than at Council Grove (Table 7). Low dissolved oxygen concentrations in the intergravel environment can reduce trout egg survival rates during the incubation period.

7. Substrate composition was most favorable for egg survival at the Champion bioassay site (Table 14).

8. Dissolved oxygen concentration, permeability, apparent velocity and substrate composition interact to influence trout egg survival in the intergravel environment.

9. Preliminary observations suggest concentrations of cadmium and zinc in the intergravel environment are not high enough to adversely affect trout egg survival rates (Table 8). Additional monitoring of copper and iron concentrations in the intergravel environment is needed to determine whether levels are high enough to influence trout egg survival rates (Glenn Phillips, Montana Department of Fish, Wildlife and Parks and Gary Ingman, Montana Department of Health and Environmental Sciences, personal communication).

10. Preliminary observations indicate concentrations of ammonia in the intergravel environment are not high enough to adversely affect trout egg survival rates (Table 8) (Glenn Phillips, Montana Department of Fish, Wildlife and Parks, personal communication).

11. Water depth and velocity remained within acceptable criteria for brown trout egg survival during the incubation period (Table 3 and Figure 1).

12. Embryo development was slower at the Champion and Cyr sites than at Council Grove (Table 10). By mid-March, 1985, the eyed egg bioassay was developed to 97.8 percent sac fry at Council Grove compared to 53.7 and 49.1 percent sac fry at Champion and Cyr, respectively.

13. Elevated concentrations of sodium and chloride ions in water samples collected from the intergravel environment at Champion and Cyr suggest Champion effluent affects intergravel water quality for a distance of at least 25.6 miles downstream from the effluent discharge (Table 9).

14. Limited electrofishing surveys indicated young-of-the-year trout were relatively more abundant in the Milltown and Superior study sections than in the Missoula and Huson sections during late summer of 1985 (Table 11).

15. Preliminary estimates of catchable rainbow trout in four study sections of the Clark Fork River are shown in Table 12. Rainbow trout provide the bulk of the sport fishery in the middle Clark Fork River. While the Clark Fork roughly doubles in size between the Milltown and Superior study sections, preliminary estimates indicate trout populations do not increase at this same magnitude. Locations of the trout population estimate study sections are shown in Table 13.

Summary

Fishery studies conducted to date on the middle Clark Fork River suggest Champion effluent affects intergravel water quality for a distance of at least 25.6 miles downstream from the discharge. Findings from a field bioassay indicated brown trout egg survival rates were lower at sites immediately downstream and 25.6 miles downstream from the pulp mill effluent than at an upstream control. Brown trout embryo development was also significantly slower at sites downstream from the pulp mill effluent than at the upstream control.

Intergravel water quality will be monitored by the Department of Fish, Wildlife and Parks (DFWP) at eight study sites on the Clark Fork River during the brown/rainbow trout incubation period in 1985-86. In addition to the Council Grove, Champion and Cyr bioassay sites established in the fall of 1984, intergravel water quality will be monitored at sites near Milltown Dam, in the main channel of the Clark Fork River near Council Grove, near the Erskine Fishing Access (several miles downstream of the Champion effluent discharge and within the mixing zone), near Huson (below the Champion mixing zone) and near Superior (also below the Champion mixing zone). This will provide a total of three monitoring sites upstream from the pulp mill effluent discharge and five downstream from the discharge.

Intergravel water quality parameters which will be monitored during the brown/rainbow trout incubation period in 1985-86 include total recoverable concentrations of iron and copper, total hardness, total alkalinity, pH,

water temperature, dissolved oxygen, conductivity, total suspended solids, volatile suspended solids and concentrations of chloride, sodium, calcium and magnesium. The intergravel studies are being conducted to continue to evaluate environmental factors potentially affecting trout egg survival rates in the Clark Fork River and to more accurately assess potential direct or indirect affects of Champion effluent discharge on trout reproductive success.

Even though the Clark Fork River approximately doubles in size between the Milltown and Superior study sections, preliminary estimates made during 1984-85 indicate trout populations do not increase at the same magnitude. DFWP will estimate trout populations in the Milltown, Missoula, Huson and Superior sections in 1986 to monitor population changes compared to earlier baseline estimates. Environmental factors potentially influencing trout population characteristics in the four study sections will also be assessed. Factors such as stream gradient, channel development, water temperature and water chemistry will be measured to aid in evaluating differences in population characteristics between study sections and to continue to more accurately evaluate whether trout population characteristics are affected by Champion effluent discharge. The Milltown and Missoula sections are located upstream from the Champion effluent while the Huson and Superior sections are located downstream from the Champion effluent and downstream from the effluent mixing zone.

DFWP will conduct electrofishing surveys in 1985-86 to document species of nongame and forage fish present and their relative abundance in the Milltown, Missoula, Huson and Superior study sections. Forage fish are important constituents in the diet of trout, particularly brown and bull trout. The surveys will aid in beginning to identify potential differences in trout food supply between the sections and in evaluating whether the trout food supply is affected by Champion effluent discharge.

Potential impacts of year round discharge of pulp mill effluents on trout populations and the sport fishery of the middle Clark Fork River represent a legitimate public concern. Additional time is needed to adequately assess potential impacts of year round discharge on trout reproductive success, trout population characteristics, trout food supply and sport fishing success rates. A minimum of five years will be required for a reliable assessment of these impacts.

Table 1. Fish species found in the Clark Fork River in Montana between Milltown Dam and the confluence of the Flathead River.

SALMONIDAE (Trout Family)	
Prosopium williamsoni - Mountain whitefish	A[1]/
Salmo clarki lewisi - Westslope cutthroat trout	R*
Salmo gairdneri - Rainbow trout	C
Salmo trutta - Brown trout	R*
Salvelinus fontinalis - Brook trout	R*
Salvelinus confluentus - Bull trout	R
ESOCIDAE (Pike Family)	
Esox lucius - Northern pike	R
CYPRINIDAE (Minnow Family)	
Mylocheilus caurinus - Peamouth	R
Ptychocheilus oregonensis - Squawfish	A
Rhinichthys cataractae - Longnose dace	C
Richardsonius balteatus - Redside shiner	A
CATOSTOMIDAE (Sucker Family)	
Catostomus catostomus - Longnose sucker	R
Catostomus macrocheilus - Largescale sucker	A
CENTRARCHIDAE (Sunfish Family)	
Micropterus salmoides - Largemouth bass	R
COTTIDAE (Sculpin Family)	
Cottus cognatus - Slimy sculpin	C

1/ Relative Abundance - A = Abundant, C = Common, R = Rare.
* Common in some tributaries of the Clark Fork in the study area.

Table 2. Study site names, river mileage locations and legal descriptions of brown trout bioassay sites.

Site No.	Site Name	Approximate River Mile	Legal Description
1	Council Grove	343.5	T13N, R20W, S06 DCC
2	Champion	338.6	T14N, R21W, S14 BBB
3	Cyr	313.0	T14N, R23W, S06 BCC

Table 3. Physical habitat parameters of brown trout egg bioassay sites in the Clark Fork River during the incubation period. Standard deviations are in parentheses.

Date	Site	Egg Type	Depth (ft) N	Depth (ft) $\bar{x}$	Mean Velocity (ft/sec) N	Mean Velocity (ft/sec) $\bar{x}$	Point Velocity (ft/sec) N	Point Velocity (ft/sec) $\bar{x}$
11/15-16/84	1	Green	6	0.94(±0.19)	6	2.09(±0.60)	6	1.09(±0.41)
"	2	Green	6	0.96(±0.05)	6	2.41(±0.11)	6	1.08(±0.42)
"	3	Green	6	1.00(±0.17)	6	1.98(±0.51)	6	1.17(±0.44)
12/8/84	1	Green	1	0.7	1	1.15	1	0.45
"	2	Green	1	0.55	1	0.1	1	0.0
"	3	Green	1	0.75	1	0.75	1	0.25
1/15-17/85	1	Green	6	0.77(±0.30)	6	1.22(±0.64)	6	0.50(±0.40)
"	2	Green	6	0.47(±0.13)	6	0.50(±0.08)	6	0.23(±0.11)
"	3	Green	6	0.28(±0.14)	6	0.09(±0.15)	-	
"	1	Eyed	5	1.29(±0.12)	5	2.28(±0.37)	5	0.78(±0.39)
"	2	Eyed	5	1.24(±0.29)	5	1.75(±0.37)	5	0.63(±0.24)
"	3	Eyed	4	0.66(±0.14)	4	2.15(±0.27)	-	
1/22-24/85	1	Green	6	0.68(±0.30)	6	1.17(±0.90)	6	0.54(±0.46)
"	2	Green	6	0.37(±0.10)	6	0.25(±0.08)	6	0.06(±0.08)
"	3	Green	6	0.99(±0.27)	6	1.88(±0.30)	6	0.76(±0.25)
"	1	Eyed	5	1.17(±0.06)	5	2.29(±0.35)	5	1.20(±0.39)
"	2	Eyed	5	1.11(±0.19)	5	1.56(±0.24)	5	0.70(±0.27)
"	3	Eyed	4	1.38(±0.38)	4	3.09(±0.71)	4	1.38(±0.31)
2/22,25/85	1	Green	6	0.72(±0.29)	6	1.14(±0.76)	6	0.37(±0.32)
"	2	Green	6	0.41(±0.13)	6	0.49(±0.16)	6	0.28(±0.20)
"	3	Green	6	0.95(±0.25)	6	1.73(±0.30)	6	0.73(±0.41)
"	1	Eyed	5	1.22(±0.10)	5	2.42(±0.29)	5	0.84(±0.18)
"	2	Eyed	5	1.21(±0.29)	5	1.77(±0.23)	5	0.78(±0.28)
"	3	Eyed	4	1.13(±0.05)	4	3.08(±0.71)	4	0.83(±0.38)
3/14-15/85	1	Green	6	0.72(±0.26)	6	1.49(±0.66)	6	0.75(±0.30)
"	2	Green	6	0.55(±0.09)	6	0.79(±0.23)	6	0.32(±0.20)
"	3	Green	6	0.90(±0.25)	6	1.79(±0.29)	6	0.73(±0.26)
"	1	Eyed	5	1.27(±0.10)	5	2.66(±0.30)	5	1.09(±0.33)
"	2	Eyed	5	1.42(±0.31)	5	1.78(±0.26)	5	0.69(±0.15)
"	3	Eyed	4	1.08(±0.10)	4	2.96(±0.57)	4	1.08(±0.10)
3/27,29 & 4/3/85	1	Green	6	0.73(±0.30)	6	1.83(±0.82)	6	1.00(±0.32)
	2	Green	6	0.70(±0.08)	6	1.38(±0.12)	6	0.63(±0.15)
"	3	Green	6	1.62(±0.19)	6	2.44(±0.19)	6	0.90(±0.33)
"	1	Eyed	5	1.29(±0.18)	5	2.47(±0.29)	5	1.42(±0.15)
"	2	Eyed	5	1.56(±0.30)	5	1.94(±0.19)	5	0.74(±0.20)
"	3	Eyed	4	2.11(±0.10)	4	2.74(±0.33)	4	0.75(±0.27)

Table 4. Groundwater flow into the Clark Fork River measured by seepage meters at brown trout egg bioassay sites. Standard deviations are in parentheses.

Site	Date	No. of measurements	Apparent velocity $ml/m^2 . min$	Apparent velocity cm/hr
2	12/19/84-1/4/85	3	0.70 (±0.69)	0.25 (±0.25)
1	2/22-3/5/85	2	0.34 (±0.15)	0.12 (±0.06)
2	2/21-3/5/85	2	0.14 (±0.04)	0.05 (±0.01)
3	2/25-3/5/85	2	0.80 (±0.04)	0.29 (±0.01)
2	3/6-3/22/85	2	1.02 (±0.37)	0.37 (±0.13)
2	3/27-4/2/85	3	-	3.71 (±2.80)

Table 5. Permeabilities at 10 C from the brown trout bioassay sites in the Clark Fork River. Standard deviations are in parentheses.

Date	Site	Egg Type	Number (N)	Permeability K_{10} (cm/min)	Permeability K_{10} (cm/hr)
11/19-20/84	1	Green	6	0.9 (±0.6)	54 (±36)
"	2	Green	6	5.0 (±2.4)	300 (±144)
"	3	Green	6	2.6 (±2.6)	156 (±156)
1/22-25/85	1	Green	6	3.4 (±0.8)	204 (±48)
"	2	Green	6	7.5 (±5.2)	450 (±312)
"	3	Green	6	10.1 (±1.4)	606 (±84)
"	1	Eyed	6	3.9 (±1.9)	234 (±114)
"	2	Eyed	6	8.3 (±4.0)	498 (±240)
"	3	Eyed	6	24.6 (±9.2)	1476 (±552)
3/28-29 & 4/3/85	1	Green	6	3.0 (±1.9)	180 (±114)
"	2	Green	6	6.0 (±4.4)	360 (±264)
"	3	Green	6	5.3 (±2.8)	318 (±168)
"	1	Eyed	6	4.4 (±2.3)	264 (±138)
"	2	Eyed	6	16.8 (±11.7)	1008 (±702)
"	3	Eyed	1	24.4	1464

Table 6. Dissolved oxygen concentrations from brown trout egg bioassay sites in the Clark Fork River. Standard deviations are in parentheses.

Site	Date	Sample Source	Egg Type	N	Dissolved Oxygen (mg/l)
1	11/15/84	Surface	-	1	11.4
1	"	Gravel	Green	4	10.9 (±0.3)
2	"	Surface	-	1	13.5
2	"	Gravel	Green	3	4.9 (±3.0)
3	11/16/84	Surface	-	1	13.9
3	"	Gravel	Green	4	12.3 (±0.5)
2	12/13/84	Surface	-	1	13.0
2	"	Gravel	Green	1	3.3
2	"	Gravel	Eyed	1	8.5
1	12/17/84	Surface	-	1	11.4
1	"	Gravel	Green	3	10.2 (±0.3)
2	"	Surface	-	1	14.1
2	"	Gravel	Green	3	10.3 (±2.1)
3	12/14/84	Surface	-	1	13.6
3	"	Gravel	Green	3	13.1 (±0.3)
1	1/30/85	Surface	-	1	12.3
1	"	Gravel	Green & Eyed	5	10.6 (±1.1)
2	1/29/85	Surface	-	2	13.7 (±0.1)
2	"	Gravel	Green	2	5.8 (±1.5)
2	"	Gravel	Eyed	2	11.7 (±1.1)
3	"	Surface	-	1	13.0
3	"	Gravel	Green	2	10.2 (±0.5)
3	"	Gravel	Eyed	3	10.7 (±1.2)
1	2/28/85	Surface	-	-	-
1	"	Gravel	Green & Eyed	5	8.7 (±0.7)
2	"	Surface	-	2	12.7 (±0.1)
2	"	Gravel	Green	3	5.2 (±2.6)
2	"	Gravel	Eyed	3	9.5 (±2.0)
3	3/1/85	Surface	-	1	11.9
3	"	Gravel	Green	5	8.2 (±1.6)
3	"	Gravel	Eyed	4	6.0 (±1.3)
1	4/1/85	Surface	-	1	12.6
1	"	Gravel	Green & Eyed	5	8.7 (±1.5)
2	"	Surface	-	1	11.7
2	"	Gravel	Green	3	0.7 (±0.4)
2	"	Gravel	Eyed	3	8.1 (±3.9)
3	"	Surface	-	1	11.4
3	"	Gravel	Green	3	8.1 (±2.2)
3	"	Gravel	Eyed	3	7.4 (±1.2)

Table 7. Overall mean dissolved oxygen concentrations from brown trout egg bioassay sites in the Clark Fork River. Standard deviations are in parentheses.

Site	Sample source	Egg type	N	Mean Dissolved Oxygen (mg/l)	Dissolved Oxygen Range (mg/l)
1	Surface	-	4	11.9 (± 0.6)	11.4 - 12.6
	Gravel	Green & eyed	21	9.6 (± 1.2)	7.2 - 12.3
2	Surface	-	8	13.1 (± 0.8)	11.7 - 14.1
	Gravel	Green	15	5.2 (± 3.6)	0.4 - 12.2
	Gravel	Eyed	9	9.4 (± 2.6)	3.9 - 12.5
3	Surface	-	5	12.8 (± 1.1)	11.4 - 13.85
	Gravel	Green	17	10.2 (± 2.5)	5.7 - 13.5
	Gravel	Eyed	10	7.8 (± 2.3)	4.2 - 11.7

Table 8. Intragravel water quality at brown trout egg bioassay sites in the Clark Fork River. Standard deviations are in parentheses.

	Site 1 Council Grove				Site 2 Champion side channel			
	Intragravel		Surface		Intragravel		Surface	
Parameter	Mean	Range	Mean	Range	Mean	Range	Mean	Range
T.S.S.(mg/l)	16.0(±10.8)	4.8-37.8	2.0(±1.0)	1.1-3.0	74.2(±108.8)	0.8-332.3	1.8(±0.1)	1.7-1.9
V.S.S.(mg/l)	3.1(± 2.1)	1.2-8.1	1.2(±0.1)	1.1-1.3	18.4(±16.8)	6.1-52.8	1.4(±0.0)	N=2
Total Alkalinity ($mg/1CaCO_3$)	109.3(±15.2)	68.0-121.0	114.0(±3.3)	109.0-118.0	344.8(±175.6)	133.0-686.0	115.2(±3.9)	109.0-119.0
Total Hardness ($mg/1CaCO_3$)	126.0(±35.1)	44.0-166.0	133.7(±1.5)	132.0-135.0	181.9(±38.4)	131.0-253.0	129.3(±3.2)	127.0-133.0
Total Recoverable								
Cu(mg/l)	<0.01	N=5	<0.01	N=2	0.02(±0.01)	0.01-0.03	<0.01	N=2
Fe(mg/l)	0.20(±0.09)	0.14-0.35	0.05(±0.0)	N=2	0.98(±0.92)	0.16-2.44	0.07(±0.0)	N=2
Cd(mg/l)	<0.005	N=5	<0.005	N=2	0.005(±0.001)	0.002-0.005	<0.005	N=2
Zn(mg/l)	0.03(±0.01)	0.01-0.04	0.006(±0.001)	0.005-0.006	0.035(±0.035)	0.005-0.10	<0.005	N=2
pH	8.06(±0.12)	7.81-8.20	8.31(±0.18)	8.14-8.60	7.87(±0.15)	7.70-8.20	8.23(±0.18)	7.94-8.39
NH_3asN(mg/l)	0.013(±0.005)	0.01-0.02	0.01(±0.00)	N=3	0.50(±0.31)	0.02-0.91	0.03(±0.03)	0.01-0.06
NO_3asN(mg/l)	0.232(±0.127)	0.142-0.321	0.101(±0.022)	0.085-0.116	0.179(±0.069)	0.130-0.228	0.107(±0.049)	0.072-0.142
PO_4asP(mg/l)	0.028(±0.009)	0.021-0.034	0.027(±0.000)	N=2	0.035(±0.010)	0.028-0.042	0.036(±0.009)	0.029-0.042
T.D.S.(mg/l)	211.4(±4.5)	208.2-214.5	214.7(±1.8)	213.4-215.9	213.7(±8.0)	208.0-219.3	225.6(±5.2)	221.9-229.2

Table 8. (Cont.)

Parameter	Site 2 Champion main channel				Site 3 Cyr			
	Intragravel		Surface		Intragravel		Surface	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
T.S.S.(mg/l)	60.1(±18.2)	47.2-73.0	2.7	N=1	12.4(±6.8)	1.9-20.1	2.7(±1.2)	1.8-4.1
V.S.S.(mg/l)	11.2(±1.6)	10.1-12.3	1.6	N=1	2.6(±1.4)	1.0-5.7	1.6(±0.3)	1.2-1.8
Total Alkalinity ($mg/lCaCO_3$)	115.3(±2.75)	112.0-118.0	115.3(±4.7)	110.0-119.0	105.3(±13.5)	76.0-118.0	112.2(±4.0)	107.0-118.0
Total Hardness ($mg/lCaCO_3$)	130.0(±4.2)	127.0-133.0	131.0	N=1	116.0(±18.7)	73.0-134.0	129.0(±8.5)	123.0-135.0
Total Recoverable								
Cu(mg/l)	<0.01	N=1	<0.01	N=1	<0.01	N=5	<0.01	N=2
Fe(mg/l)	0.30	N=1	0.07	N=1	0.11(±0.07)	0.04-0.22	0.045(±0.007)	0.04-0.05
Cd(mg/l)	<0.005	N=1	0.005	N=1	<0.005	N=5	<0.005	N=2
Zn(mg/l)	0.03	N=1	0.005	N=1	0.016(±0.015)	0.005-0.04	0.0065(±0.002)	0.005-0.008
pH	8.06(±0.19)	7.90-8.33	8.40(±0.10)	8.30-8.50	8.18(±0.10)	8.04-8.32	8.35(±0.10)	8.25-8.50
NH_3asN(mg/l)	0.03(±0.02)	0.02-0.04	0.01	N=1	0.01(±0.004)	0.01-0.02	0.01(±0.0)	N=3
NO_3asN(mg/l)	0.21(±0.04)	0.179-0.237	0.108(±0.064)	0.063-0.153	0.179(±0.069)	0.130-0.228	0.110(±0.061)	0.067-0.153
PO_4asP(mg/l)	0.08(±0.04)	0.05-0.10	0.035(±0.008)	0.029-0.040	0.035(±0.010)	0.028-0.042	0.029(±0.004)	0.026-0.031
T.D.S.(mg/l)	226.8(±2.47)	225.0-228.5	224.3(±1.1)	223.5-225.1	213.7(±8.0)	208.0-219.3	215.3(±3.2)	213.0-217.5

Table 9. Major cation/anion concentrations from brown trout egg bioassay sites in the Clark Fork River.

Date	Site	Sample Source	Mean concentration (mg/l)					
			SO_4^{-2}	Cl^-	Na^+	K^+	Ca^{+2}	Mg^{+2}
3/5/85	1	Gravel	21.2	3.1	7.5	2.3	30.0	11.1
		Surface	21.4	3.1	7.3	2.1	30.6	11.0
	2	Gravel-side channel	142.0	43.1	144.0	4.5	34.9	17.7
		Surface-side channel	24.0	5.0	13.6	2.2	30.0	11.0
		Gravel-main river	21.6	4.9	12.6	2.3	30.3	9.7
		Surface-main river	21.6	4.9	12.6	2.3	30.3	9.7
	3	Gravel	24.5	4.1	10.2	2.5	29.7	10.9
		Surface	21.0	4.1	10.1	2.4	30.0	10.8
4/2/85	1	Gravel	22.7	2.8	6.6	2.0	30.9	10.2
		Surface	25.9	2.7	7.1	1.8	31.8	10.4
	2	Gravel-side channel	404.0	123.0	388.0	8.5	68.2	28.5
		Surface-side channel	31.0	4.1	11.4	1.9	30.8	10.0
		Gravel-main river	30.2	4.1	11.4	2.0	31.8	10.5
		Surface-main river	31.2	4.0	11.4	1.8	31.2	10.0
	3	Gravel	21.9	3.6	9.1	2.1	29.8	10.1
		Surface	27.0	3.5	9.3	1.8	30.6	9.6

Table 10. Egg survival from three bioassay sites in the Clark Fork River.

Date	Site	Egg Type	Percent Survival	Eggs Live	Eggs Dead	Stage of Development (Live Eggs)
11/19-20/84	1	Green	98.1	159	3	100% Green
"	2	Green	98.8	163	2	100% Green
"	3	Green	95.6	151	7	100% Green
12/8/84	1	Green	95.0	151	8	100% Green
"	2	Green	92.0	149	13	100% Green
"	3	Green	92.5	149	12	100% Green
1/22-24/85	1	Green	89.0	145	18	100% Green
"	2	Green	78.8	130	35	100% Green
"	3	Green	94.3	150	9	100% Green
"	1	Eyed	91.4	148	14	99.3% Eyed,0.7% Sac Fry
"	2	Eyed	92.6	150	12	100% Eyed
"	3	Eyed	92.0	150	13	100% Eyed
2/21,22&25/85	1	Green	92.0	149	13	2.0% Green,96.6% Eyed,1.3% Sac Fry
"	2	Green	0.0*	0	162	-
"	3	Green	0.0*	0	158	-
"	1	Eyed	91.5	150	14	95.3% Eyed,4.7% Sac Fry
"	2	Eyed	70.8	114	47	100% Eyed
"	3	Eyed	83.9	135	26	98.5% Eyed,1.5% Sac Fry
3/14-15/85	1	Green	86.8	46	7	4.3% Green,91.3% Eyed,4.3% Sac Fry
"	2	Green	0.0	0	164	-
"	3	Green	0.0	0	157	-
"	1	Eyed	85.3	139	24	2.2% Eyed,97.8% Sac Fry
"	2	Eyed	66.3	108	55	46.3% Eyed,53.7% Sac Fry
"	3	Eyed	65.8	106	55	50.9% Eyed,49.1% Sac Fry
3/27,29 & 4/2/85	1	Green	91.7	143	13	2.1% Green,94.4% Eyed,3.5% Sac Fry
	2	Green	0.0	0	162	-
	3	Green	0.0	0	161	-
	1	Eyed	83.2	134	27	100% Sac Fry
	2	Eyed	72.4	110	42	100% Sac Fry
	3	Eyed	48.6	52	55	100% Sac Fry

* Green egg bioassay terminated due to egg freeze-up.

Table 11. Average size and relative abundance of young-of-the-year trout sampled by electrofishing in four study sections of the Clark Fork River during late summer 1985.

Study Section	Date	Trout Species	Average Length (mm)	Juvenile Trout Electrofished/Hour
Milltown	8/26/85	Rainbow	57	7.1
		Brown	90	10.7
Missoula (side channel)	8/28/85	Rainbow	76	1.7
		Brown	94	10.0
Missoula (main river)	8/28/85	Rainbow	63	1.4
		Brown	-	0.0
Huson	8/30 & 9/4/85	Rainbow	60	3.6
		Brown	77	0.3
Superior	9/5/85	Rainbow	58	14.6
		Brown	81	1.1

Table 12. Preliminary trout population estimates in four study sections of the Clark Fork River.

Study Section	Date of Estimate	Fish Species	Section Length(mi)	Catchable[1] Trout/Section	Catchable[1] Trout/Mile
Missoula	Sept. 1984	Rainbow	8.6	1506	175
Missoula	June 1985	Rainbow	8.6	1804	210
Milltown	June 1985	Rainbow	3.6	1035	288
Superior	July 1985	Rainbow	6.3	1382	219
Huson	Sept. 1985	Rainbow	4.5	1749	389

1/ Catchable trout 7-inches total length and larger

Table 13. Location, length and river mile index boundaries of fish population study sections on the Clark Fork River.

Section Name	Description of Location	Section Length (mi)	River Mile Index Boundaries
Milltown	Milltown Dam to 2.8 miles upstream from confluence of Rattlesnake Cr.	3.4	364.4 to 361.0
Missoula	Confluence of Bitterroot R. to 0.5 mile upstream from Harper Bridge	8.6	350.5 to 341.9
Huson	Confluence of Sixmile Cr. to 4.0 miles upstream from confluence of Petty Cr.	4.5	328.2 to 323.7
Superior	Confluence of Cedar Cr. to confluence of Dry Cr.	6.3	286.6 to 280.3

Table 14. Fine substrate composition at green and eyed brown trout egg bioassay sites on the Clark Fork River.

Egg Type	Bioassay Site	Percentage of materials passing through 0.84-mm sieve (± standard deviation)*
Green	1	23.20% (± 1.61)
	2	10.59% (± 3.39)
	3	19.07% (± 2.93)
Eyed	1	16.06% (± 4.21)
	2	12.68% (± 0.85)
	3	23.26% (± 11.04)

* Spawning success may be impaired where bottom materials contain more than 15 to 20 percent of materials passing through an 0.84-mm sieve (McNeil, W. J. and W. H. Ahnell, 1964. Success of pink salmon spawning relative to size of spawning bed materials. USDI, Fish and Wildlife Service. Special Scientific Report: Fisheries No. 469).

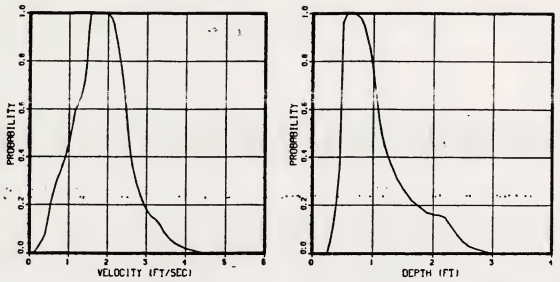

Figure 1. Probability of use criteria curves for brown trout spawning (from Bovee 1978).

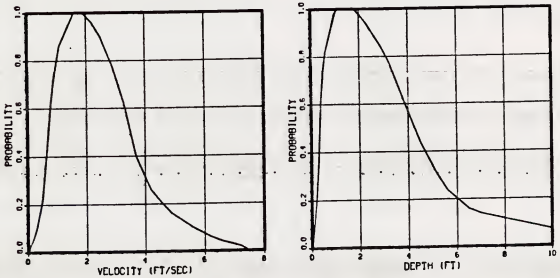

Figure 2. Probability of use criteria curves for brown trout egg incubation (from Bovee 1978).